SER# 32956

SWEEP GENERATOR RS-50

PART I OPERATING

OPERATING AND INSTRUCTION MANUAL

Texscan

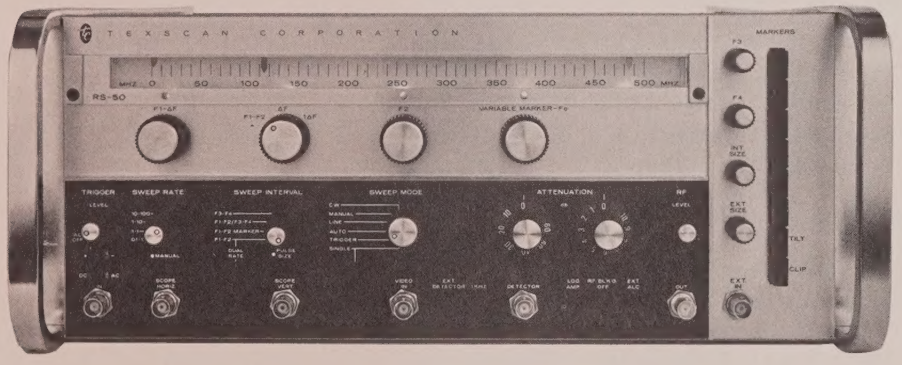
CERTIFICATION

Texscan Corporation certifies that this instrument has been thoroughly tested, inspected, and found to be in compliance with its published specifications.

OPERATING AND INSTRUCTION MANUAL

MODEL RS-50

SWEEP GENERATOR



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SECTION 1

SPECIFICATIONS

1.1	FREQUENCY RANGE	The RS-50 can be centered at any frequency between 2 MHz and 500 MHz and sweep anywhere within that range.
1.2	FREQUENCY DIAL ACCURACY	The dial accuracy on all three indicators, F1-F2 and Variable-Fo are within ±2% of the units maximum frequency.
	Except in ΔF mode:	ΔF provides a calibrated sweep width within 6% of the units maximum frequency.
1.3	SWEEP WIDTH	F1-F2 - Sweep width adjustable from minimum of 2 MHz to maximum sweep width of 500 MHz. ΔF/Fo - minimum sweep width as limited by residual FM is approximately 100 KHz.
1.4	RF OUTPUT	The RF output is at least 1 volt rms into a 50 ohm load.
1.5	ATTENUATION	0-10 db vernier, 0-70 db in 1 db steps.
1.6	FLATNESS	The flatness is better than ±0.25 db at maximum sweep width (tested with a CD-51 detector).
1.7	HARMONIC DISTORTION AND SPURIOUS	At 1.0V rms output and from 10 MHz to 500 MHz, all unwanted frequency components are more than 25 db below the fundamental output.
1.8	LINEARITY	Linearity is accurate to within ±1% of the units maximum frequency.

1.9 MARKERS: Birdy Markers-The unit has a birdy bypass marker system with provisions for up to six single frequency or harmonic markers. An external marker input is provided which can be used with a CW source to produce a variable marker. A 100 mv signal produces a marker greater than 1 volt peak to peak. The marker can be rectified for x-y recordings.

Pulse Markers-F3 and F4 are uncalibrated pulse markers which indicate the portion of the sweep for dual sweep width operation. A calibrated variable pulse marker is also provided.

1.10	HORIZONTAL DRIVE	At least 10V peak to peak.
1.11	BLANKING OUT	At least 20V positive during trace.
1.12	MODULATION	
	FM/Ø lock	Maximum 5V/MHz
	AM	Maximum 3V peak to peak, 30% modulation.
	1 KHz	Internal square wave 100%.
1.13	SIZE	6 7/8" X 17" X 16"
1.14	CONSTRUCTION	Aluminum with G-10 aluminum circuit board.
1.15	WEIGHT	34 lbs.
1.16	POWER (AC LINE)	25 watts

SECTION 2

GENERAL DESCRIPTION

2.1 GENERAL INFORMATION

Texscan Corporation's RS-50 is a broad sweep, variable rate, external triggered, dual sweep width, start-stop, solid state sweep signal generator. It is designed for applications within the 2 to 500 MHz frequency range.

The transistors used are all silicon, and the low frequency circuits are assembled on high-quality plug-in circuit boards for maximum reliability and serviceability.

The RS-50 covers the frequency range of 2 MHz to 500 MHz. A block diagram of the sweep system is shown in figure 2-1. The output frequency of 2 to 500 MHz is derived by taking the low level heterodyne output of two oscillators and amplifying this to 1.0V rms. Low level mixing is employed to maintain a low spurious output signal.

2.2 INTRODUCTION

As shown in figure 2-1, the RS-50 sweep generator consists of eight major sections: (1) rate circuit, (2) start-stop adder and blanking, (3) linearity, (4) leveler and log amplifier, (5) pulse marker system, (6) birdy marker system, (7) RF oscillators,mixer, video amplifier, and (8) power supply.

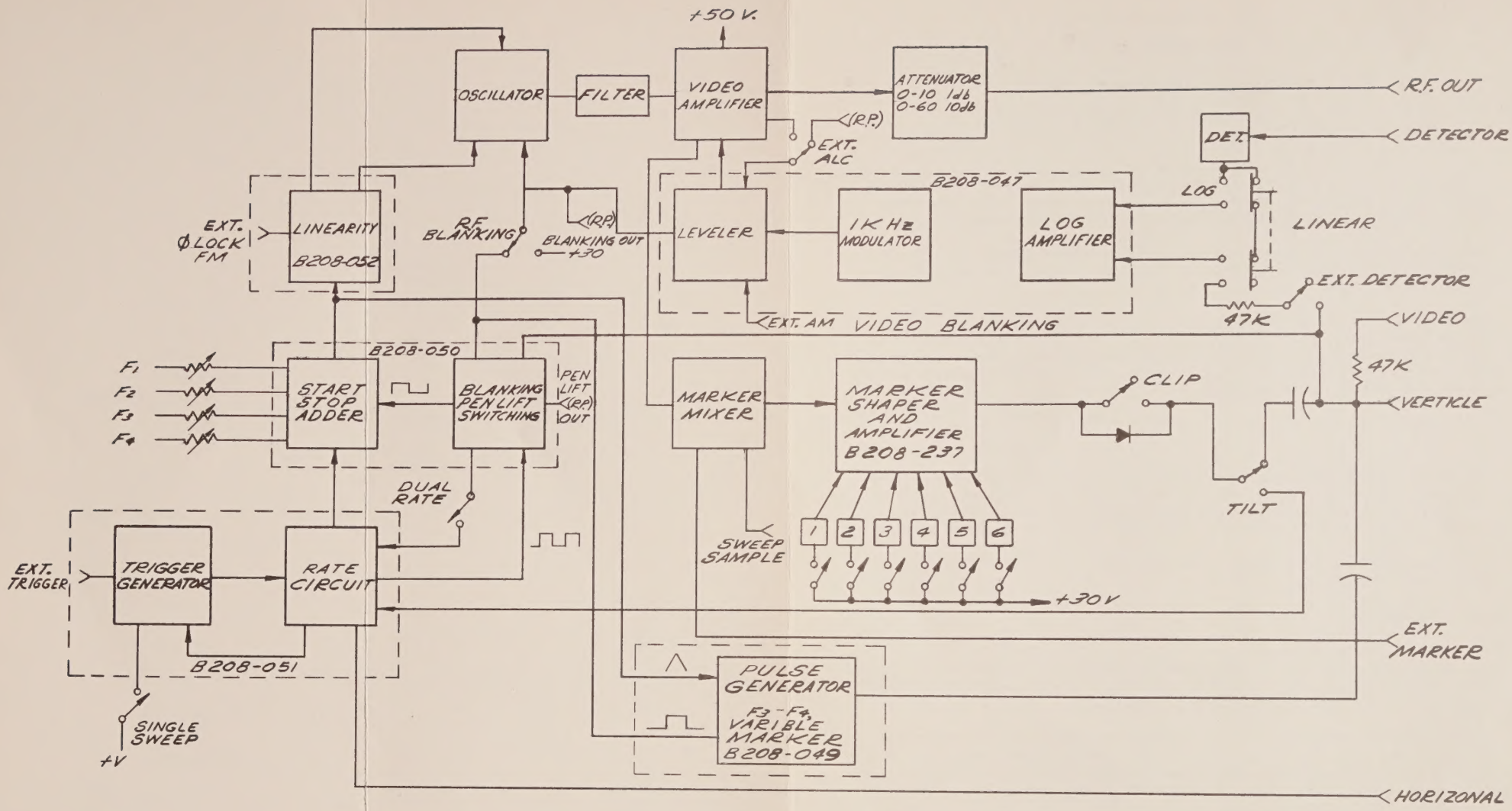
A more detailed block diagram of the time base and electronic switching is given in figure 2-2.

2.3 DESCRIPTION

The heart of the RS Series sweep signal generator is the rate circuit. This circuit provides all of the voltage waveforms necessary to operate all the functions of the unit except the RF circuitry.

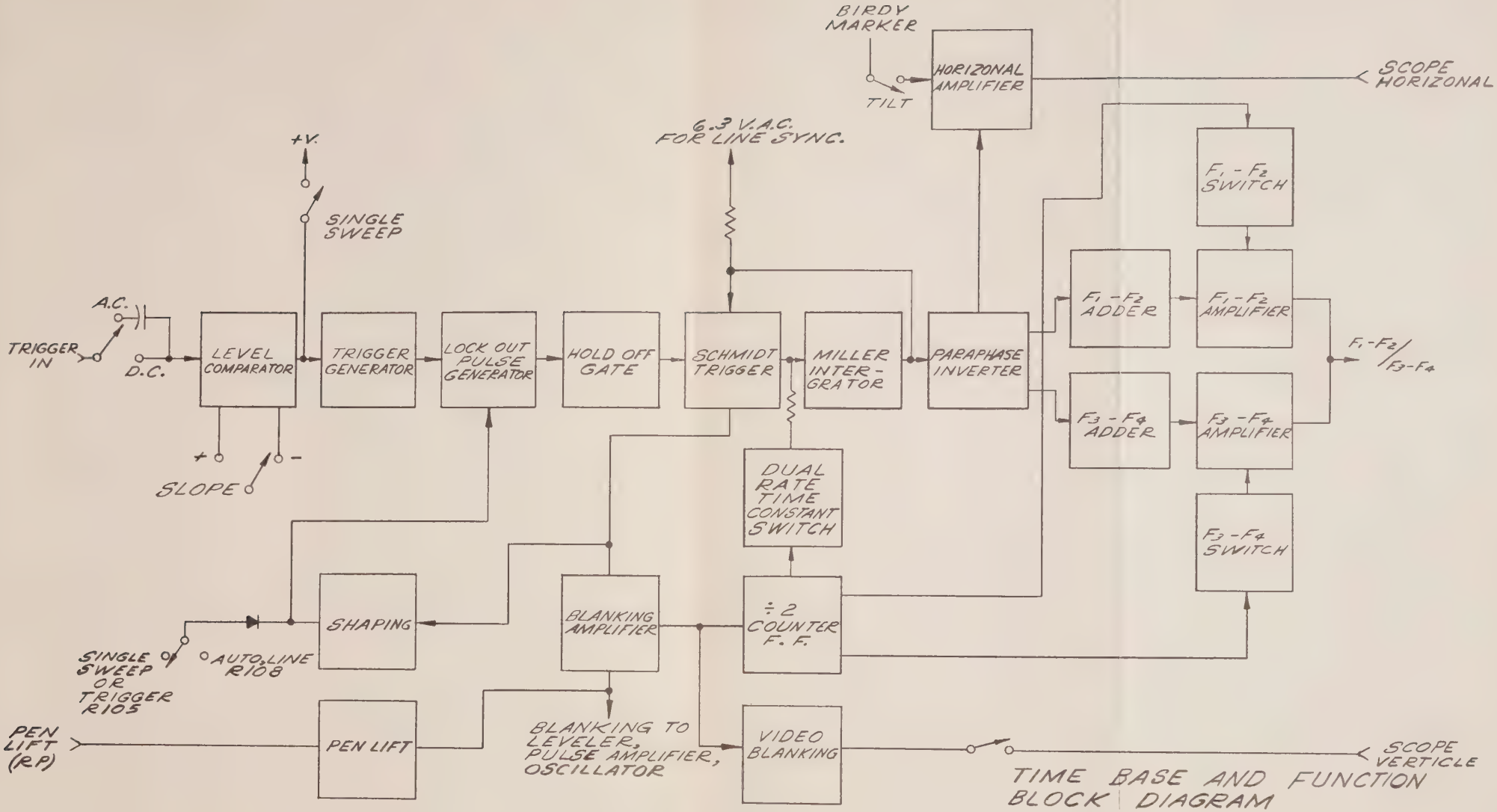
This circuit has six modes of operation as determined by the sweep mode control. The modes are: cw, manual, line, auto, trigger, and single sweep. The six modes are achieved by changing the operating characteristics of the basic rate circuit consisting of a Schmidt Trigger and Millter Integrator. See figure 2-3.

Transistors Q109 and Q110 are incorporated in the Schmidt Trigger, and Q112, Q113, and Q114 are used in the Miller Integrator. This combination of a Schmidt Trigger and Miller Integrator provides square wave and triangular



GENERAL OVERALL BLOCK DIAGRAM

FIGURE 2-1



TIME BASE AND FUNCTION BLOCK DIAGRAM

FIGURE 2-2

wave outputs with a fixed phase relationship. The square wave is present at the collector of Q110; the triangular wave, at the emitter of Q114. The circuit provides these signals with constant amplitude over the frequency range of the rate circuit.

2.3.1 Auto

In the auto position, the rate circuit is adjustable over four decade frequency bands as determined by the position of the sweep rate switch. The rate circuit will sweep from 100 seconds per sweep to 100 sweeps per second.

Capacitors C114 and C120,C115,C116, and C117 make up the capacity part of the time constant for the four sweep rates. Two ganged variable resistors consisting of R803C and R803B provide the vernier frequency range over each sweep rate decade.

2.3.2 Line

In the line position, a 60 Hz signal from the power transformer is coupled through C103 and C104 to the base of Q109. The circuit locks the rate generator to the line frequency. The other poles of the switch convert the circuit time constants, etc, to insure the locking and provide the same amplitude as in the auto mode.

2.3.3 Manual

In the manual mode of operation, the rate circuit is bypassed and a DC voltage is provided at the output of the rate circuit. R803A section of the rate circuit vernier provides adjustment of this DC voltage through the same amplitude swing normally available from the rate circuit.

2.3.4 CW

In the cw position, the entire rate circuit and start-stop circuitry is disabled leaving only the linearity circuit in operation to determine the cw output frequency. When the unit is switched from start-stop mode to the conventional Fo/ΔF mode, the variable marker pot is switched to the linearity circuit and provides an adjustable DC level which tunes the sweeper through the frequency range as indicated by the pointer associated with the variable marker - Fo control.

2.3.5 Trigger

In the trigger position, the sweep mode switch connects the necessary circuitry to inhibit the rate circuit in such a way that the blanking is in the off state and no triangular waveform is being generated. The rate circuit is inhibited by Q107 which is a hold off gate. An external trigger signal is fed to a voltage comparator, Q101 and Q102. The trigger level control sets the proper input waveform level at the collector of Q102 to cause the

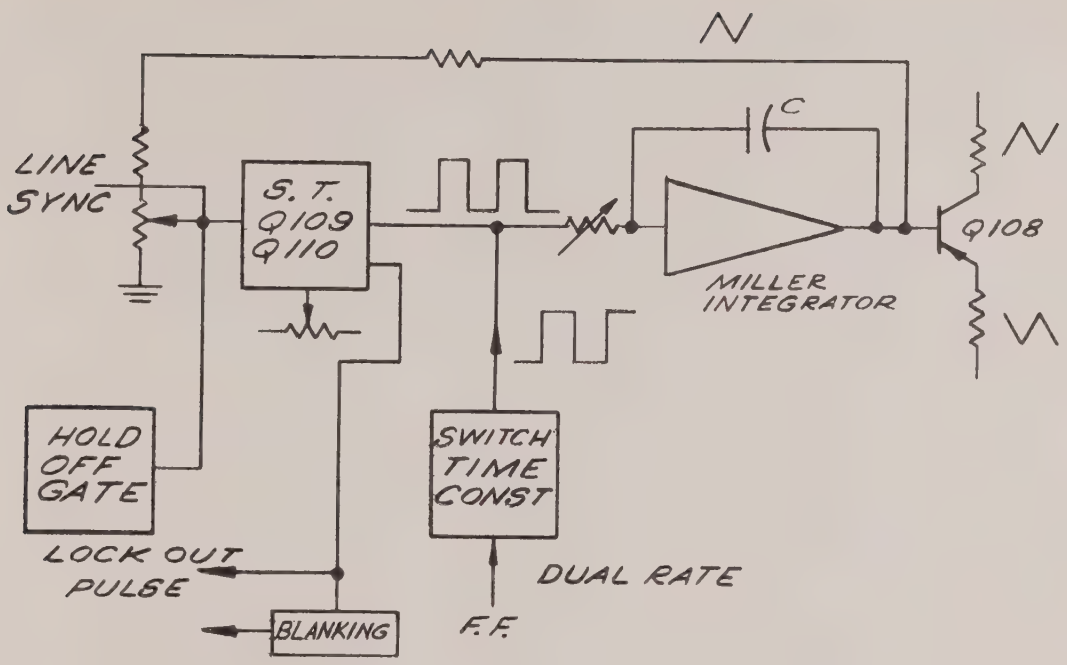
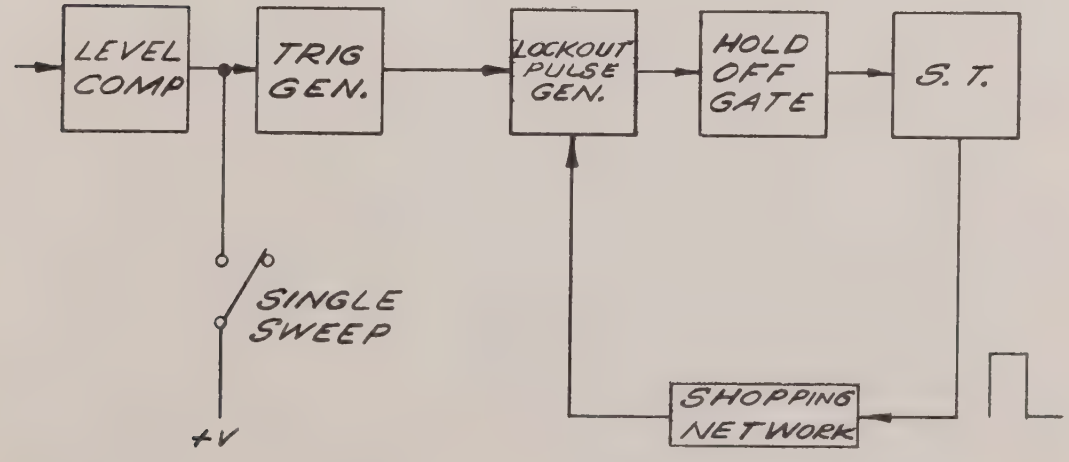


FIGURE 2-3 RATE CIRCUIT



TRIGGER CIRCUIT

FIGURE 2-4

Schmidt Trigger, Q103 and Q104 to generate a pulse. This pulse is shaped and coupled to the hold off circuitry consisting of another Schmidt Trigger, Q105 and Q106, and the hold off gate, Q107, R105 establishes a negative bias on the base of Q105 which in turn holds the rate circuit off. When a positive going pulse of sufficient amplitude to overcome the negative bias is created by an external signal, the Schmidt Trigger, Q105 and Q106 turns off the hold off gate and allows the rate circuit to start integrating upward in voltage. When the integrator output reaches a certain level, the Schmidt Trigger, Q109 and Q110 changes state and the integrator will start integrating back down, but a negative going pulse is generated which turns the hold off circuit back on, and the integrator will integrate back down and the entire unit returns to its pre-triggered condition. See figure 2-2 and 2-4.

2.3.6 Single Sweep

In single sweep, the trigger circuit functions exactly the same except when the single sweep button is pushed, a positive voltage is momentarily applied to the base of Q103 which actuates the trigger sequence.

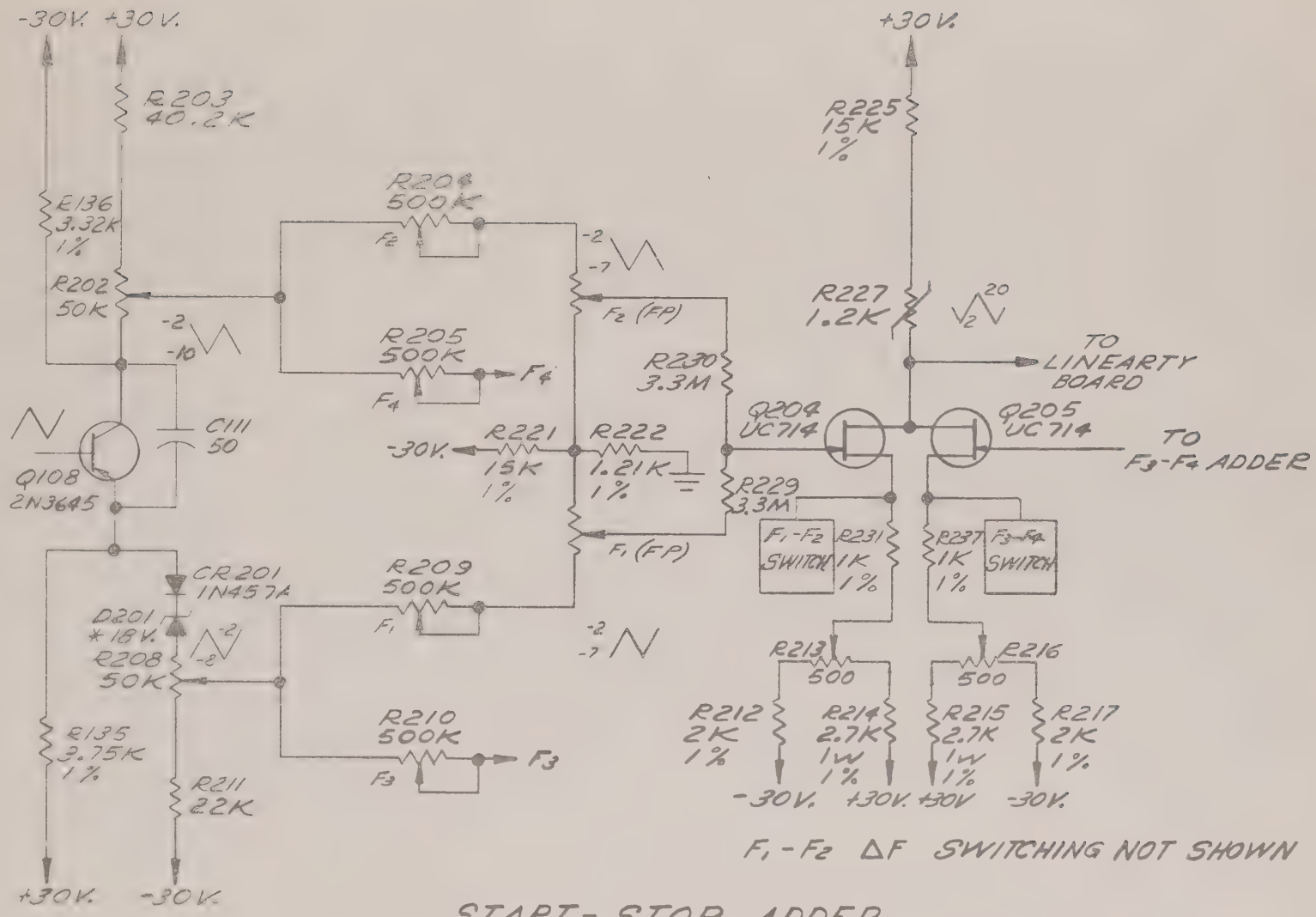
In the other modes, R108 biases the trigger circuit in such a manner to allow the rate circuit to free run or be syncronized with the line.

2.4 START-STOP ADDER

The output from Q114 of the rate circuit is coupled to a paraphase amplifier, Q108. See figure 2-5. This transistor provides two outputs; the emitter waveform being exactly the same as the input and the collector waveform is an inverted waveform of approximately the same amplitude and at a different DC level. Two internal controls, R202 and R208 are used to set the upper most peak of both the regular and inverted waveform to the same DC level as appears at the junction of R221 and R222. One side of F_1 and F_2 are tied to this junction, a voltage which is the same as the peak of the regular and inverted waveform, plus the amplitude of the waveforms are made equal by adjusting R204 and R209, and applied to the other end of F_1 and F_2 pot, then through two resistor adders, R229 and R230 at the junction (gate of Q204) appears a waveform where F_1 will vary only one peak and F_2, the other peak. This is the start-stop signal which when amplified by Q204 is coupled to the oscillator, provides independent adjustment of the end frequencies of the swept signal.

2.5 DUAL SWEEP WIDTH

At the wipers of R202 and R208 is an exact duplicate of the F_1-F_2 start-stop adder circuit except F_3 and F_4 controls are in this circuit. The other adder consisting of R236 and R237 (gate of Q205) (when the amplitudes have been properly set by R205 and R210) is a start-stop signal which also sets the end of the swept signal. When the sweep interval switch is placed in F_1-F_2/F_3-F_4, the sweep generator sweeps between F_1 and F_2 and



START-STOP ADDER

FIGURE 2-5

then during the next blanking period, sweeps between F_3 and F_4. This is accomplished by alternately connecting the two adder outputs (drains of Q204 and Q205) to the oscillator via the linearity circuit as shown in figure 2-6. The blanking signal is fed to a counter flip-flop which divides the blanking frequency by two and provides the switching signal for the dual sweep width operation. Two transistors, Q201 and Q202 provide the switching voltage to alternate the FET adder output.

2.5.1 Dual Rate

The square wave present at the collector of Q110 is coupled to Q208 and inverted in phase. It is fed to Q209, an emitter follower and Q210, another emitter follower. The waveform present on the emitter of Q209, also is different and the resulting pulse is used to trigger the divide by two flip-flop for the dual sweep width and dual sweep rate operation. When the dual rate button is pushed, the divide-by-two flip-flop output is coupled to Q203 which is connected back to the rate circuit. When Q203 conducts, it changes the charging time constant of the Miller Integrator in the rate circuit, and hence on alternate sweeps, the sweep time is lengthened by about 30%. See figure 2-2. This dual rate feature is not operative when the sweep interval switch is set to F_1-F_2/F_3-F_4 since the flip-flop is now being used for dual sweep width.

2.5.2 Video Blanking

The inverted blanking present on the collector of Q208 is also coupled to an FET, Q211 which is used for video blanking. The scope vertical terminal is grounded through Q211 when it conducts providing a zero reference retrace. This circuit may be disabled with a slide switch on the plug-in board.

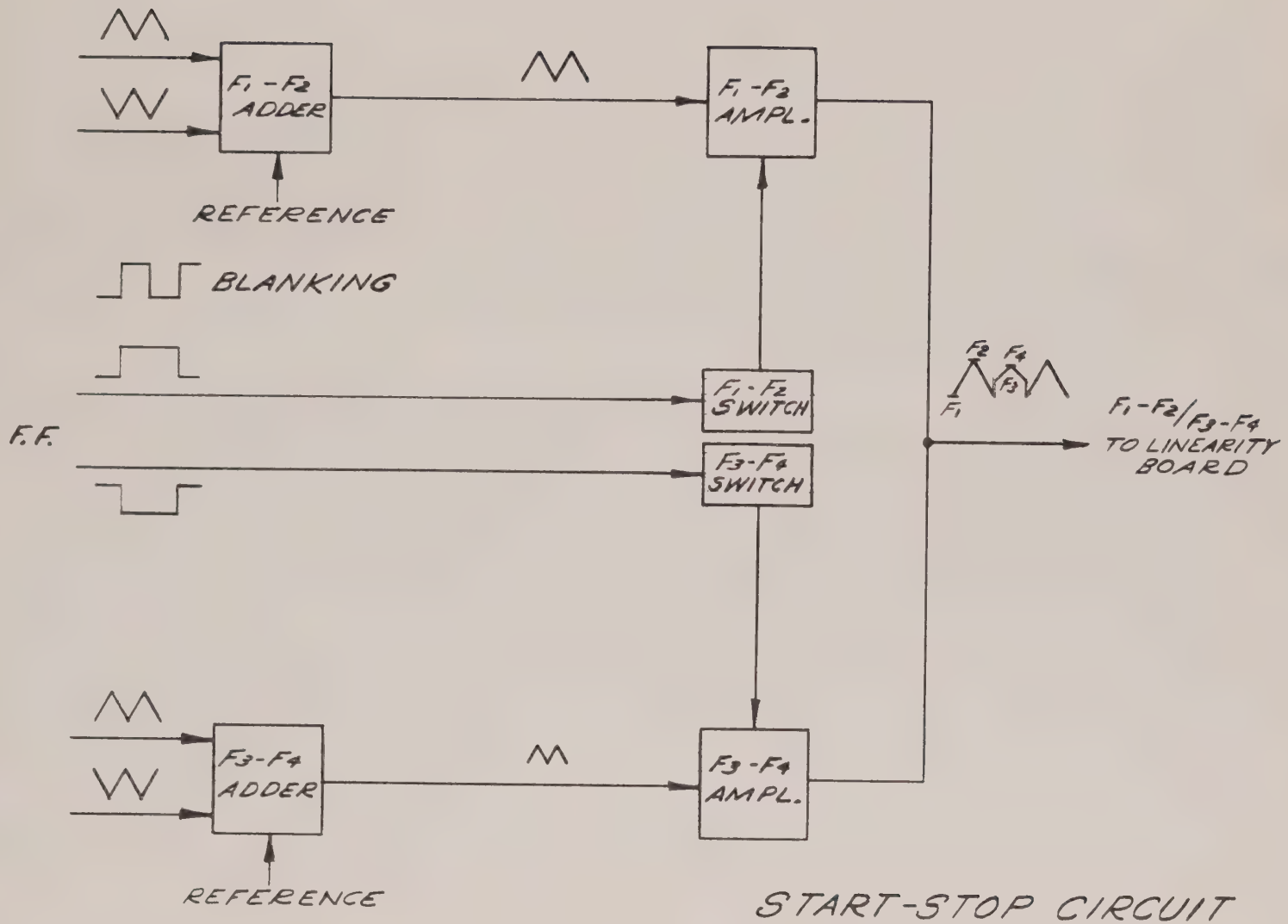
2.5.3 RF Blanking and Pen Lift

The output of Q210 is used for blanked B+ for the sweep oscillators, the pulse markers, and to blank the leveler. Also on the two slowest sweep time positions, the blanking is coupled to Q212 and Q213 to operate a relay used to pen lift on an external recorder. See figure 2-7. A slide switch determines if the rear panel pen lift connector is to be grounded during retrace or grounded during trace time.

2.5.4 Blanking and 1 KHz

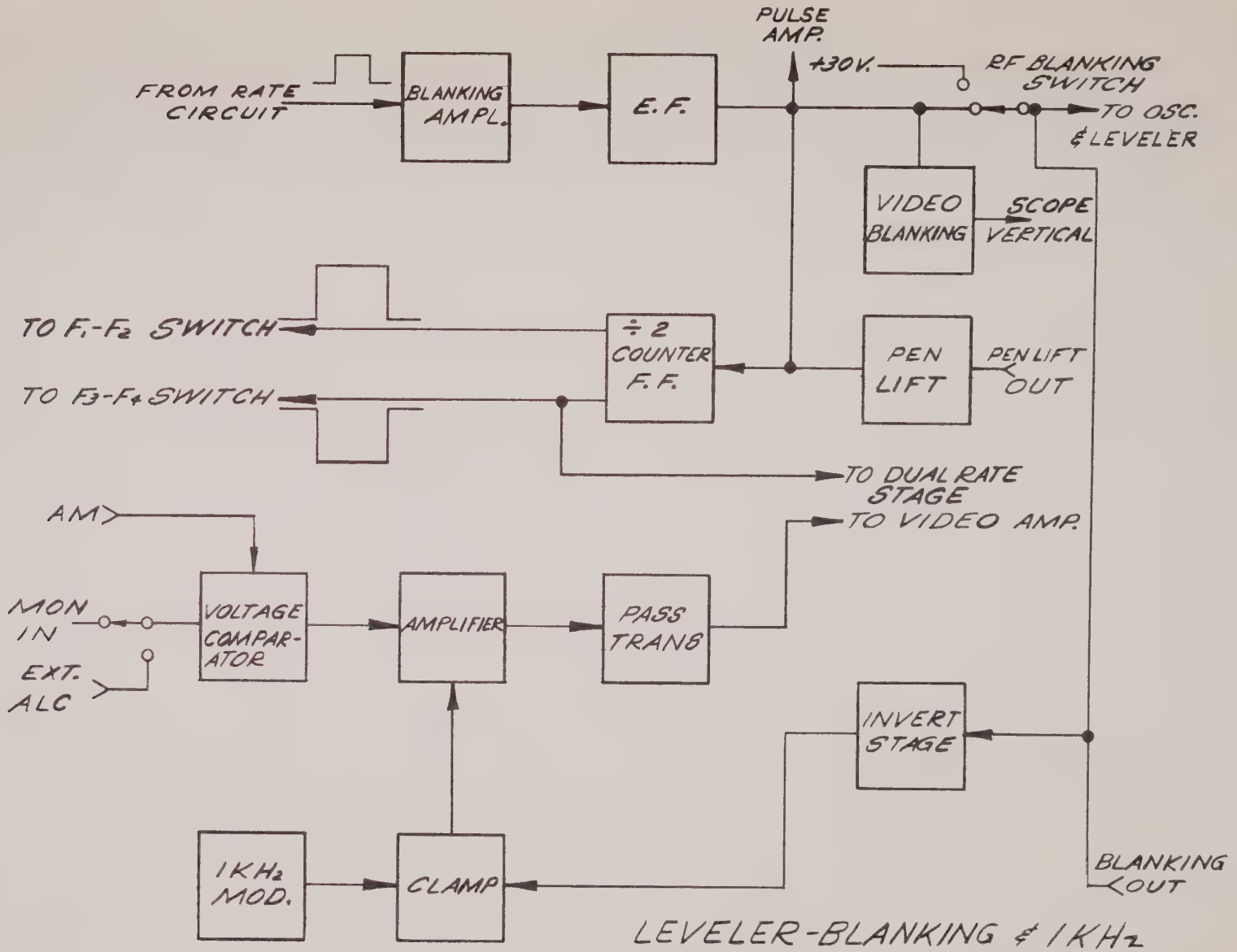
When the front panel RF blanking button is pushed, the output of Q210 is disconnected from the sweep oscillators and leveler. Also rear panel blanking out connector is disconnected. A +30V is connected in its place. The outputwill be present during trace and retrace, and if a reference retrace is desired, the video blanking must be turned on. Video blanking is not recommended at low levels due to offset caused by leakage in the FET.

In the leveler, Q457, Q456, and Q453 are used to provide blanking of the leveler during retrace. During retrace, the leveled B+ is removed from the video amplifier. A 1 KHz multivibrator is also provided which turns



START-STOP CIRCUIT

FIGURE 2-6



LEVELER-BLANKING & 1KH2

FIGURE 2-7

the leveler on or off at a 1 KHz rate to provide 1 KHz 100% modulation in all modes of operation.

2.5.5 Tuning Mode

When the unit is switched from start-stop to the conventional Fo-ΔF mode, the F_1 and F_2 controls are removed from the adder circuit and replaced by two pots, R813 and R814 which have been set to give the same amplitude signal out of the adder as would be provided if the F_1 and F_2 controls were set for maximum sweep width. F_3 and F_4 still function as normal except the F_3-F_4 maximum frequency is limited by the setting F_1. In this mode of operation, the F_1 control now becomes a calibrated ΔF or sweep width.

2.6 LINEARITY

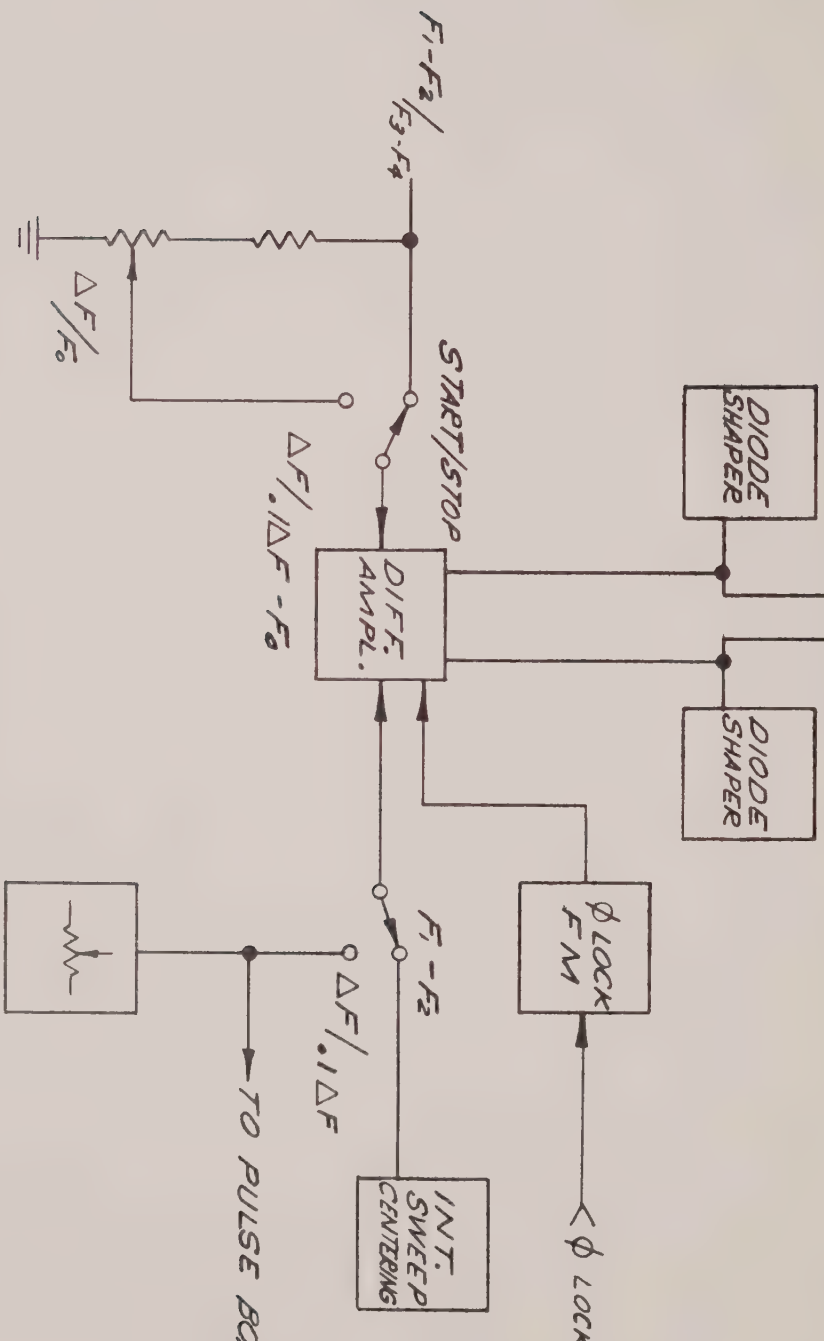
An emitter follower using Q701 is the coupling stage between the start-stop adder output circuit and the linearity circuit. The emitter follower output is coupled through R717, R719, and R724 which are used to set the amplitude and DC level of the triangular waveform for proper operation in both start-stop and conventional operation. The waveform is amplified by a differential amplifier. Q702 and Q703, and present at each collector is a waveform of sufficient amplitude and 180° phase difference to sweep the oscillators in the proper manner. See figure 2-8.

The diode break circuitry consisting of CR701, CR702, CR703, CR704, CR705, and CR706 distorts the drive signals at the collectors of the differential amplitifer. This circuit is piece wise linear. For example, for any assumed combination of forward and back biased diodes, the circuit has a linear characteristic. As the voltages at the collectors of these two transistors increase, these diodes sequencially conduct and the resultant waveform is distorted. The shape of this waveform can be adjusted with the potentiometers included in this circuit. These two, 180° out of phase, distorted, drive voltages are coupled to the varactors in the two sweep oscillators. In the start-stop mode, R725 establishes the center frequency of the sweep. In the ΔF mode, R817 is the adjustable calibrated front panel control that tunes center frequency.

For phaselock and external FM, Q704 couples a signal into the base of the differential amplifier which varies the voltage to the sweep oscillator and shifts their frequency accordingly.

2.7 SWEEP OSCILLATORS AND MIXER

The two sweep oscillators, mixer, and low-pass filter are shown in figure 6-15. The two sweep oscillators have essentially the same characteristics, each being a tuned line varactor swept oscillator. One oscillator, using transistor Q501, sweeps through the frequency range of 1350 MHz to 1600 MHz. The sweep drive voltage for this oscillator is coupled to the varac-



LINEARITY

FIGURE 2-8

tor, CV501, which changes the electronic length of the tuned line, thereby changing the oscillator's output frequency.

The second sweep oscillator, using transistor, Q502 sweeps within the range of 1350 MHz to 1100 MHz. The varactor in this circuit is CV502. The outputs of these two sweep oscillators are coupled to the mixer diode, CR501, and the lower sideband output from this mixer is filtered in the low-pass filter, Z501, and delivered to the video amplifier. As the one oscillator is sweeping down in frequency, the other is sweeping up; consequently, the resultant output sweep width is twice as great as that provided by either oscillator.

Center frequency is controlled by varying the DC level of the sweep drive to each oscillator, while sweep width is changed by varying the amplitude of the distorted drive signal. The outputs of the two sweep oscillators are very loosely coupled to CR501 so that the mixing is accomplished at extremely low signal levels within the square law region of the mixing diode. This results in a very low spurious output signal.

2.8 VIDEO AMPLIFIER AND LEVELER

The circuitry shown in figure 6-12 and 6-15, consists of a video amplifier, monitor, leveler, and an output attenuator. The video amplifier amplifies the output from the low-pass filter described above.

This video amplifier has a relatively flat frequency response from 5.0 MHz to 500 MHz. There are four stages of gain consisting of Q401 thru Q404, and their associated circuitry. Each stage is of the common emitter configuration and is essentially identical to the other three.

The output of the video amplifier at the collector of Q404 is coupled to Z401, a feed-through termination, consisting of a precision 50 ohm resistor which serves to establish the output impedance of the video amplifier. The output from Z401 is fed through the rotary attenuators to the RF out connector on the front panel.

A sample of the RF output at Z401 is rectified and filtered by the monitor circuit consisting of CR401, C434, C435, and R433. The resulting negative signal is fed to the automatic leveling circuit consisting of Q454 and Q455, which form a differential amplifier. The monitor signal is amplified and reversed in phase in Q454. The other half of this differential amplifier, Q455, has its base connected to a stable reference voltage which sets the operating point of the amplifier. The unit can be amplitude modulated by feeding in a waveform on the connector provided on the rear panel. The signal from the collector of Q454 is again amplified and reversed in phase by Q452. This signal is applied to emitter follower, Q451. The output from Q451 is used as B+ voltage for the first three stages of the video amplifier.

This closed loop amplifier thus detects any changes in RF output at the monitor point, the junction of CR401, Z401, and R434, and supplies a pro-

perly phased change in B+ voltage to the video amplifier which results in a constant amplitude to flat RF output.

Because the leveler is maintaining a constant RF output voltage at the monitor point, this point is a zero impedance constant voltage point, consequently, Z401 creates the source impedance for the sweep generator.

The reference point in this amplifier system, the base of Q455 is connected to the front panel RF vernier control. By varying this control, the operating point of the differential amplifier is changed which allows the RF output level to be changed.

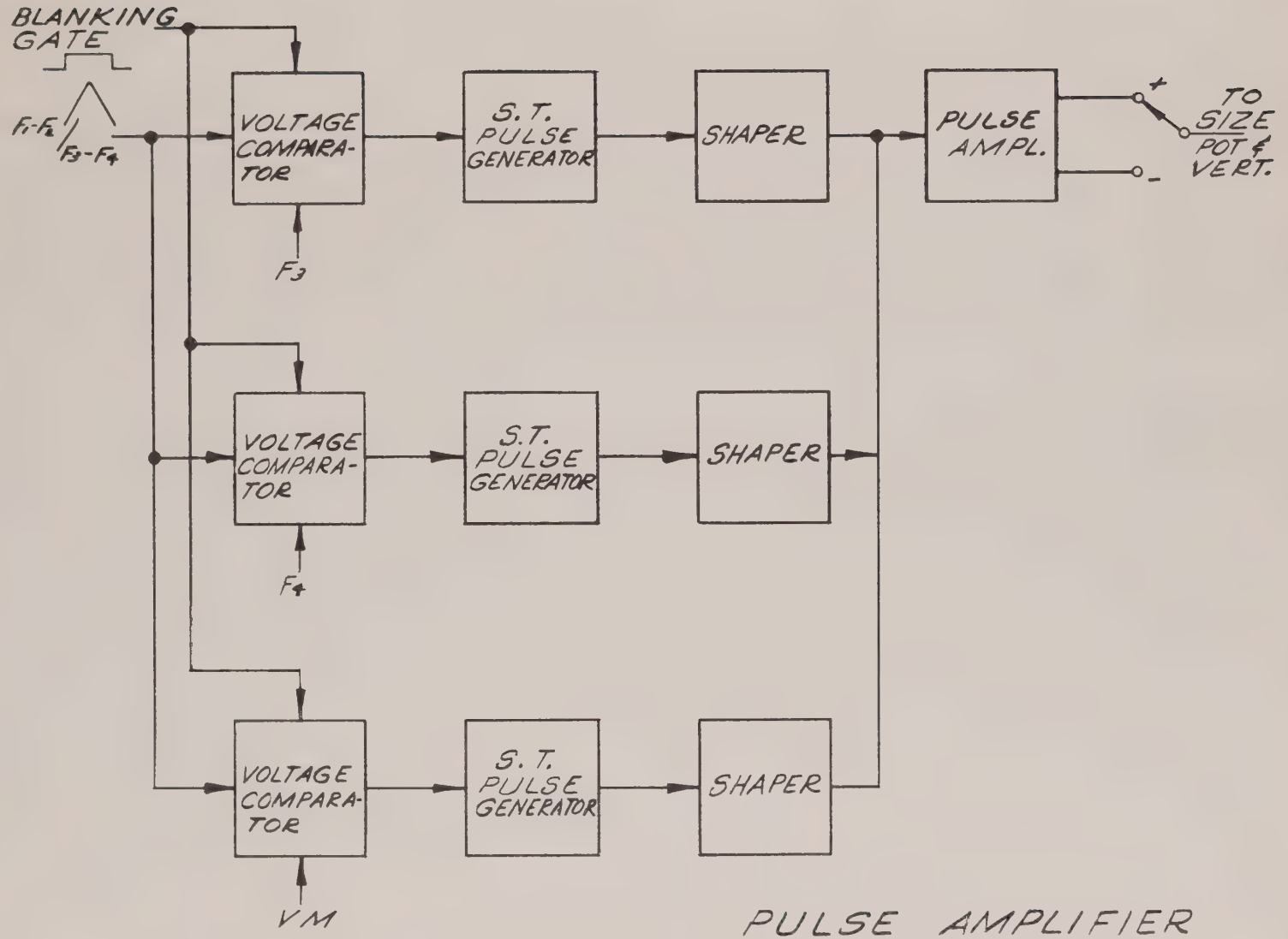
CR451 in the emitter of Q451 prevents back biasing of the oscillator transistors and damage to them in the event of a component failure in the leveler.

Included within the unit is a switch, S812 which bypasses the internal monitor and connects the leveler circuit to a back panel external ALC input connector. This allows the unit to be leveled at some remote location if the user provides a detected monitor signal from the leveling point.

A sample of the RF output for use in the marker circuitry is coupled through R434 to the marker/mixer. This sample of the swept signal is necessary for production of markers in the birdy-by-pass system.

2.9 PULSE MARKERS

The pulse markers are derived from the triangular waveform out of the start-stop adder as shown in figure 2-9. The triangular waveform is coupled into one side of a voltage comparator, Q601A. A DC level is coupled into the other side of the comparator, Q601B, from a front panel control. The DC voltage sets the level of the triangular waveform at the collector of Q601A. Connected to this collector is a Schmidt Trigger, Q603 and Q604 which changes state as the triangular wavform present at the collector goes more positive thru a certain value which is the trigger point of the Schmidt Trigger. The output of the Schmidt Trigger is differentiated to give a sharp pulse and fed through a diode adder to a pulse amplifier, Q645. The variable marker, and F_4 are also generated in identical circuits as described above with the variable markers coupled to Q645 all the time, but F_3 and F_4 are connected only when the sweep interval control is in the F_1-F_2 markers and F_1-F_2/F_3-F_4 position. The Schmidt Trigger hystersis is such that at narrow start-stop sweep width settings, the triangular waveform may not be sufficient to turn the Schmidt Trigger on and off. The blanking voltage is coupled to the voltage comparators of the three pulse circuits to switch the collector voltage over a large range to insure resetting the Schmidt Trigger. If the F_1-F_2 controls are reversed such that F_2 is the lower frequency, and the unit sweeps backward, no pulses will be present.



PULSE AMPLIFIER

FIGURE 2-9

2.10 BIRDY AMPLIFIER

The birdy amplifier system consists of a series of common emitter amplifier stages and an amplifier bandpass shaping circuit which is used to shape the birdy markers.

The birdy outputs from the plug-in markers are amplified in Q301, Q302, and Q303 shaped by a variable bandpass network. The shaper pot, R325 provides about a 2 to 1 change in bandwidth of the birdy marker and further amplified in Q305. The resultant amplified birdy is coupled to the scope vertical connector on the front panel or if horizontal markers are required, the birdy marker is connected to the horizontal amplifier.

Diode CR301, when inserted in series with the marker output will clip off the negative half for x-y recorder applications.

The external marker birdy from the marker mixer is amplified in Q304 and subsequently shaped by the same circuit as above and amplified in Q305.

As shown in figure 2-10, one amplification stage is provided for two plug-in marker sockets. One amplifier is provided for the external marker birdy, and the outputs from all four amplifiers are tied together at the input to the shaping circuit.

2.10.1 Plug-In Markers

Six plug-in marker receptacles are provided which are activated from switches on the front panel. These switches, S301, S302, S303, S304, S305, and S306 as shown in figure 6-9, switch the B+ to these marker sockets, thereby turning off (or on) the marker plug-ins. Solid state plug-in markers are available for either single frequency or harmonic marking. See figure 2-11 for plug-in marker installation.

2.10.2 Log Amplifier

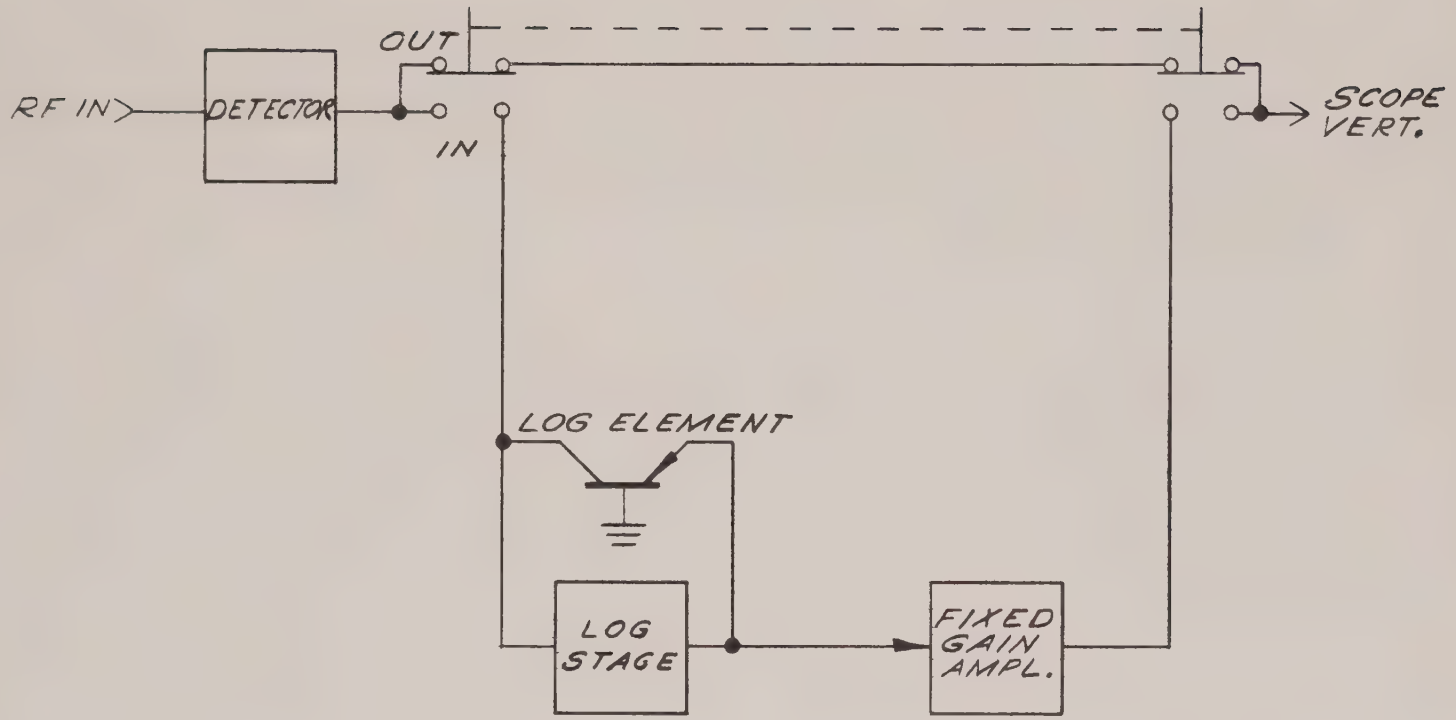
The logarithmic amplifier consists primarily of a linear integrated circuit operational amplifier IC451, and feedback transistor, Q460. The output of the operational amplifier is adjusted by the balance control, R479, such that the base-emitter junction is forward biased. The short circuit IC versus Veb transfer characteristics of the logging transistor is accurately logarithmic over a large dynamic range. In this configuration, with the built in detector connected to the input of the logarithmic amplifier, the output of IC451 is a logarithmic function of the input RF voltage. See figure 2-12.

Since this output is not sufficient in amplitude to equal the normal detector output, a fixed gain amplifier consisting of IC452 is added. The output from the stage is coupled to the scope vertical. The output amplitude is adjusted by R492 and the DC level set by R482. The integrated circuits require a lower voltage than is normally avaiable and

BIRDY AMPLIFIER
FIGURE 2-10

TYPICAL MARKER INSTALLATION
AND HOOK-UP

FIGURE 2-11



LOG AMPLIFIER

FIGURE 2-12

hence, two zener supplies consisting of D451 for +15V and D452 for -15V are contained on this board.

2.11 POWER SUPPLY

The DC power supply for this unit is shown in figure 6-8. This circuit provides regulated and current limited ±30V, ±110V, and a regulated ±7V. An unregulated ±50V is also supplied. The input transformer, T1 is designed so that the unit will operate from either 115V or 230V line. Switch, S2, on the power supply board selects either input voltage. The unit is usually shipped with S2 in the 115V position.

SECTION 3

OPERATING INSTRUCTIONS

3.1 FRONT PANEL CONTROLS AND CONNECTORS

3.1.1. F_1-F_2

F_1 and F_2 are used to vary the start and stop frequencies of the swept output. A slide rule dial with indicators is used to provide exceptional resolution.

3.1.2 Tuning Mode

In the F_1-F_2 start/stop position of the tuning mode control, a pulse marker is present and is used as a calibrated variable marker. In the ΔF mode, F_1-ΔF becomes a calibrated sweep width or ΔF control and the variable marker becomes a calibrated center frequency control, Fo. In the .1ΔF the calibrated sweep width scale is divided by ten or a maximum sweep width of 50 MHz.

3.1.3 RF Level Control

This control is used to provide vernier control of RF output over a 10 db range.

3.1.4 RF Attenuators

Two rotary attenuators are provided at the RF output of the generator. These two rotary attenuators can be used to vary the output level by 70 db with a resolution of 1 db.

3.1.5 Sweep Interval Control

This function switch is used to select among four different modes of swept output.

1. F_1-F_2 mode is a normal start/stop sweep mode.
2. F_1-F_2 with markers - This mode provides the same swept output as F_1-F_2 mode with the addition of two pulse markers identified as F_3 and F_4. The amplitude of these markers can be varied with a front panel control. The position of these markers can be varied by adjusting the F_3 and F_4 frequency controls.
3. F_3-F_4 mode - In this mode, the sweep generator will sweep as if F_3 and F_4 were the start and stop frequencies.
4. F_1-F_2/F_3-F_4 - The sweep generator on alternate cycles of swept output sweeps from F_1 to F_2 and then from F_3 and F_4 providing a dual trace presentation which can be used to expand certain areas for careful examination of test circuit characteristics.

3.1.6 Pulse Marker Size

The potentiometer control is used to vary pulse marker amplitude.

3.1.7 Dual Rate Control

This push-button switch, which operates in all, but F_1-F_2/F_3-F_4 mode, activates a special feature which allows the user to conveniently set sweep rate at the highest possible value while still obtaining an undistorted bandpass presentation. When this circuit is energized, on alternate cycles of the swept output, the sweep speed is varied resulting in two displaced presentations if the circuit response is too slow for the sweep rate setting.

3.1.8 Sweep Rate Control

This switch and potentiometer combination provides control of the rate at which the swept output is varied. Sweep times from 0.01 to 100 seconds are provided with the potentiometer providing a continuously variable adjustment at each range setting. In the manual sweep rate mode, this same control can be used to manually sweep the unit for careful investigation of certain portions of the test circuit's characteristic curve.

3.1.9 1 KHz Modulation

This push-button control, when energized, amplitude modulates the RF output at a 1 KHz rate. Square wave modulation is provided with modulation depth extending to complete turn off.

3.1.10 Sweep Mode Control

This control is used to switch the internal sweep generator time base among one of six different modes of operation.

3.1.10.1 Single Sweep Mode

In this switch position, the internal time base generator will sweep over one cycle when energized, thereby, providing a convenient means of obtaining an x-y display. The speed at which this one cycle will be completed is determined by the sweep rate control.

3.1.10.2 Triggered Sweep

In this mode, the time base generator can be triggered from an external source.

3.1.10.3 Automatic

Automatic is the normal sweep generator mode of operation with the sweep rate control switch and potentiometer combination controlling the rate of swept RF output.

3.1.10.4 Line Rate Mode

In this position, the sweep generator output will vary at 50/60 Hz line rate frequency.

3.1.10.5 Manual Position

In this mode, the concentric pot in the sweep rate control can be used to manually sweep the output.

3.1.10.6 CW Mode

In this mode of operation, RF blanking during retrace time is deactivated and the generator operates as a CW signal generator with Fo controlling the output frequency. Tuning mode must be in ΔF or .1ΔF.

3.1.11 Single Sweep Trigger

With the sweep mode switch in its single sweep position, this push button starts one cycle of the internal time base generator resulting in one cycle of swept RF output over the frequency range selected with the sweep interval and frequency controls.

3.1.12 Trigger Level and Power On-Off Switch AC-DC, + or -

This control is used to turn on the AC power to the unit and also select the trigger level when the sweep mode switch is set for triggered sweep. The slide switches allow selection of + or - trigger slopes on either AC or DC triggering when in the triggered sweep mode.

3.1.13 RF Output Connector

The swept or CW output from the generator is available at this terminal.

3.1.14 External ALC Control

This switch can be used to convert from internal leveling to external monitor operation. When testing circuits distant from the generator, an external monitor can be used to level the instrument at the input to the device under test. The switch provides selection of this external mode of operation or the normal internal leveling circuitry provided with the instrument. If no external monitor is employed, this switch can be used to deactivate the internal automatic leveling circuitry.

3.1.15 RF Level Blanking Off

When activated, the swept RF output is no longer blanked during retrace. If a zero level retrace line is desired in this mode, video blanking is provided and can be turned on or off with an internal slide switch. This provides the necessary reference base line and also eliminates possible transients which could result from switching the RF output.

3.1.16 Logarithmic Amplifier Selection Switch

The output from the test device can be detected and logarithmically amplified within the sweep generator. This switch is used to select detection, or detection and logarithmic amplification. It also connects the amplifier or detector output to the vertical oscilloscope connector.

3.1.17 Detector Input Connector

The RF output from the circuit under test is inserted at this connector if the internal detector is to be used.

3.1.18 Video Input Connector

If an external detector is employed and it is desired to add markers to the detected output, then the detected signal is inserted at this connector. The external detector switch must be activated. See figure 3-3.

3.1.19 Vertical Output Connector

This connector provides the vertical input to the x-y display oscilloscope used in most test systems.

3.1.20 Horizontal Output Connector

A triangular waveform of approximately 10 volts peak to peak is provided at this connector for oscilloscope horizontal drive.

3.1.21 Trigger Input Connector

If the sweep generator is being triggered from an external voltage source, that source should be connected to this terminal.

3.1.22 F_3-F_4 Frequency Controls

These two controls are used to vary the position of the F_3 and F_4 pulse markers on the detected output display while operating in either the F_1-F_2 with markers or F_1-F_2/F_3-F_4 modes of operation.

3.1.23 Marker Size Control

One control is provided to vary the amplitude of internal birdy markers. Up to six internal harmonic or single frequency markers can be supplied and this control adjusts the amplitude of the output of all of these six markers if energized. The external marker control varies the amplitude of the birdy marker which results if an external generator is connected to the external marker input terminal.

3.1.24 External Marker Connector

If an external signal generator is used as a marker generator to identify frequency, it is inserted at this connector.

MARKERS
F3
F4
INT SIZE
EXT SIZE
EXT IN
TEXSCAN CORPORATION
VARIABLE MARKER-Fo
MHz
RS-50

3.1.25 Marker Switch Control

Six switches are provided, each one of which energizes an internal plug-in marker socket. Up to six markers can be selected.

3.1.26 Marker Tilt Switch

This switch can be used to convert the birdy marker presentation from vertical to horizontal markers for more convenient frequency identification of sharp skirts.

3.1.27 Clip - Rectified Birdy Marker Switch

When an x-y recorder is used to display the test circuit characteristics and marker identification is desired on this recorded output, the normal birdy presentation is averaged by the recorder, thereby, losing the markers. This switch, if energized, rectifies the birdy markers resulting in clear identification of frequency when using this x-y recorder method of presentation.

3.2 REAR PANEL CONTROLS AND CONNECTORS

3.2.1 RF Level Minimum, R902

Establishes the minimum output level controlled with the RF level vernier on the front panel. See figure 3-2.

3.2.2 RF Level Maximum, R901

Establishes the maximum output level controlled with the RF level vernier on the front panel.

3.2.3 Pen Lift

Available on this connector is a set of contacts which ground the center pin during trace or retrace depending on setting of S202.

3.2.4 FM/Phase Lock

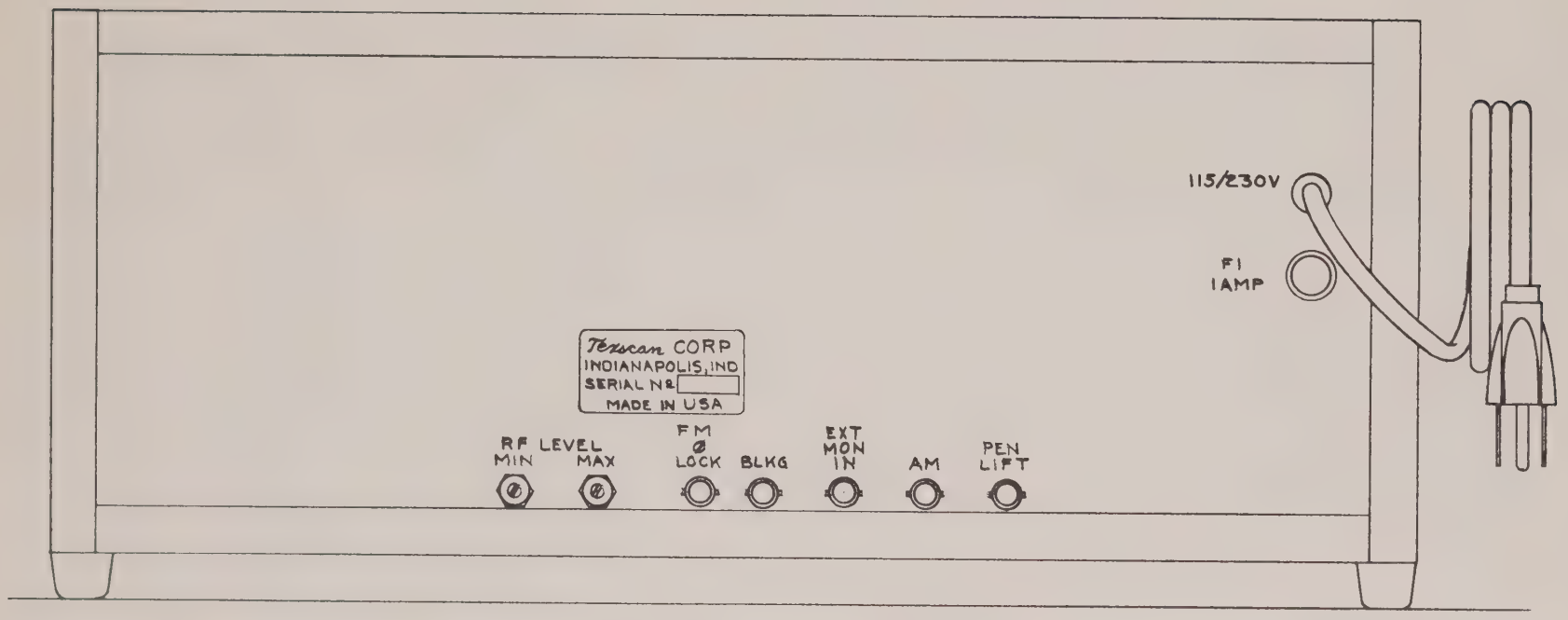
The sweep oscillator may be shifted in frequency for either modulation or locking purposes with a voltage on this terminal.

3.2.5 Blanking

The blanking voltage selected by the front panel RF blanking switch is present at this connector.

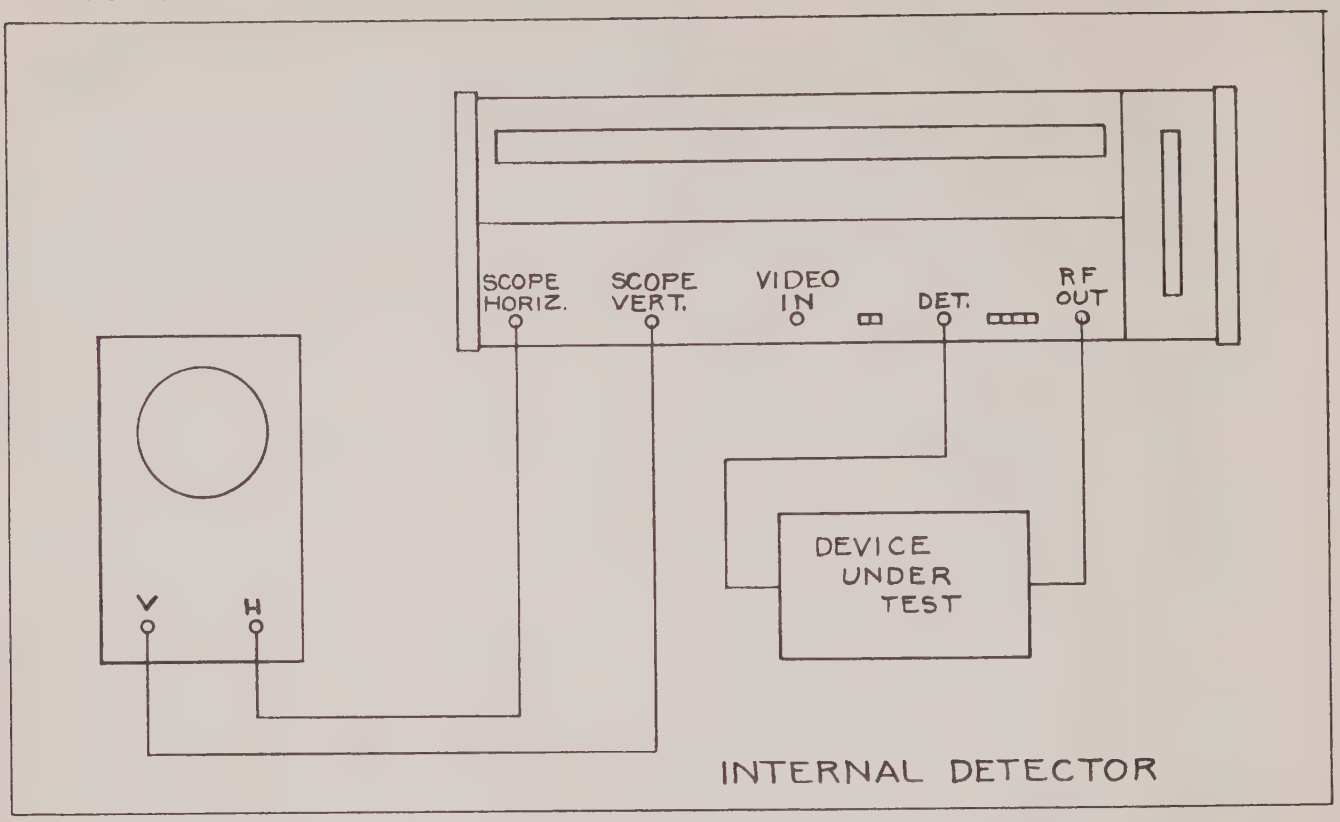
3.2.6 External ALC

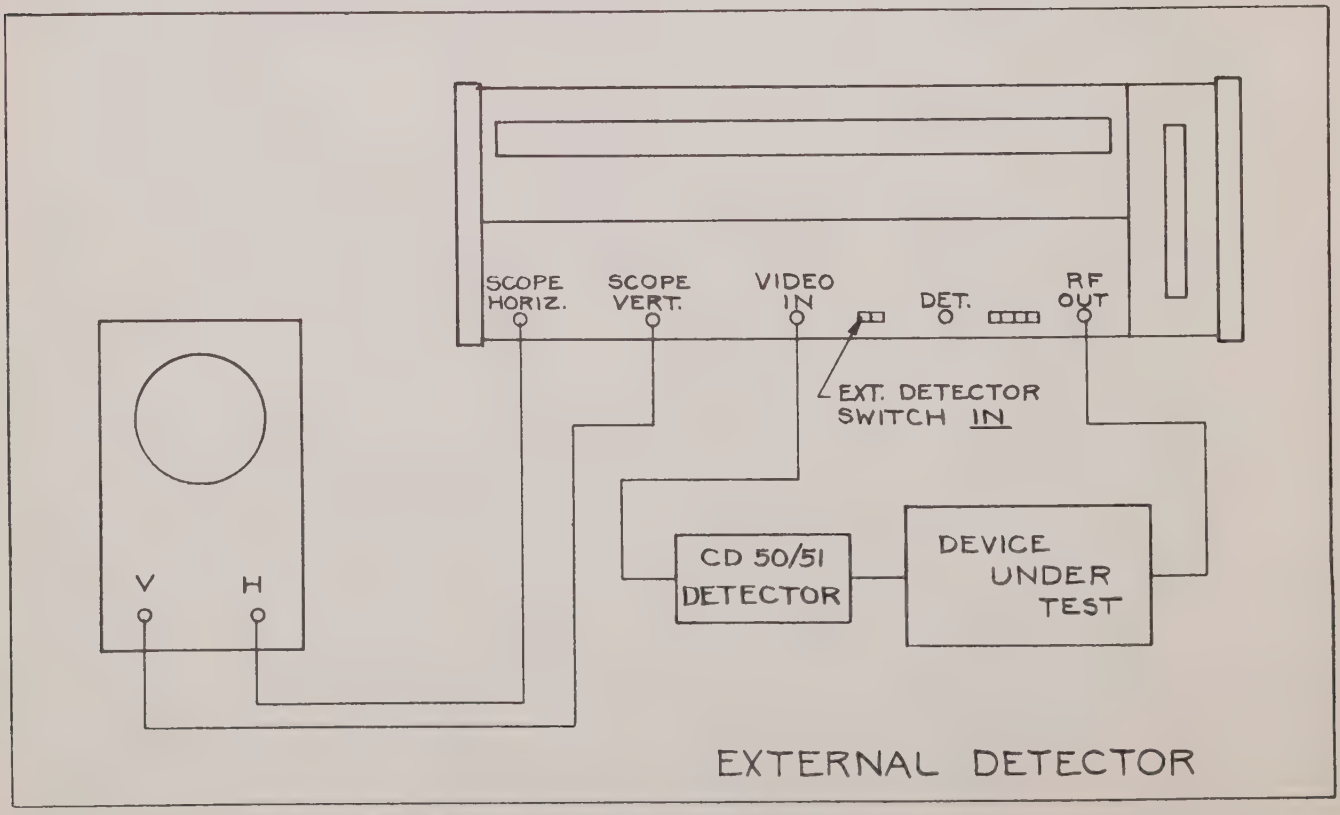
The DC output from an external monitor may be fed into this connector and provide a leveled output at the external monitor if the front panel external ALC switch is activated.



REAR PANEL CONNECTORS AND CONTROLS

FIGURE 3-2





TYPICAL TEST SETUP
FIGURE 3-3

3.2.7 AM

The amplitude of the RF output may be modulated by coupling in a signal on this connector.

SECTION 4

ADJUSTMENT PROCEDURE

4.1 INTRODUCTION

The adjustments and test of this instrument can be accomplished with the following auxiliary test equipment--an oscilloscope (such as HP-130), a VTVM, and a multimeter. It is suggested that the reader familiarize himself with the unit's circuit operation by reading Section 2 before attempting alignment of the instrument. Test of the unit for spurious level and harmonic distortion requires a high frequency oscilloscope and a sampling scope or spectrum analyzer (such as HP-8551B).

Section 4.2 gives a discussion of the internal controls which require identification during alignment of the unit. Subsequent sections describe in detail the alignment procedure for each circuit. All internal controls are properly adjusted at the factory and only minor adjustments should be required in the field due to aging or changing of components.

4.2 EXPLANATION OF INTERNAL CONTROLS

Refer to figure 4-1 to identify the location of each of the following controls:

4.2.1 R8, +30V Adjust

Adjusts the output voltage of the +30 volt power supply.

4.2.2 R14, -30V Adjust

Adjusts the output voltage of the -30 volt power supply.

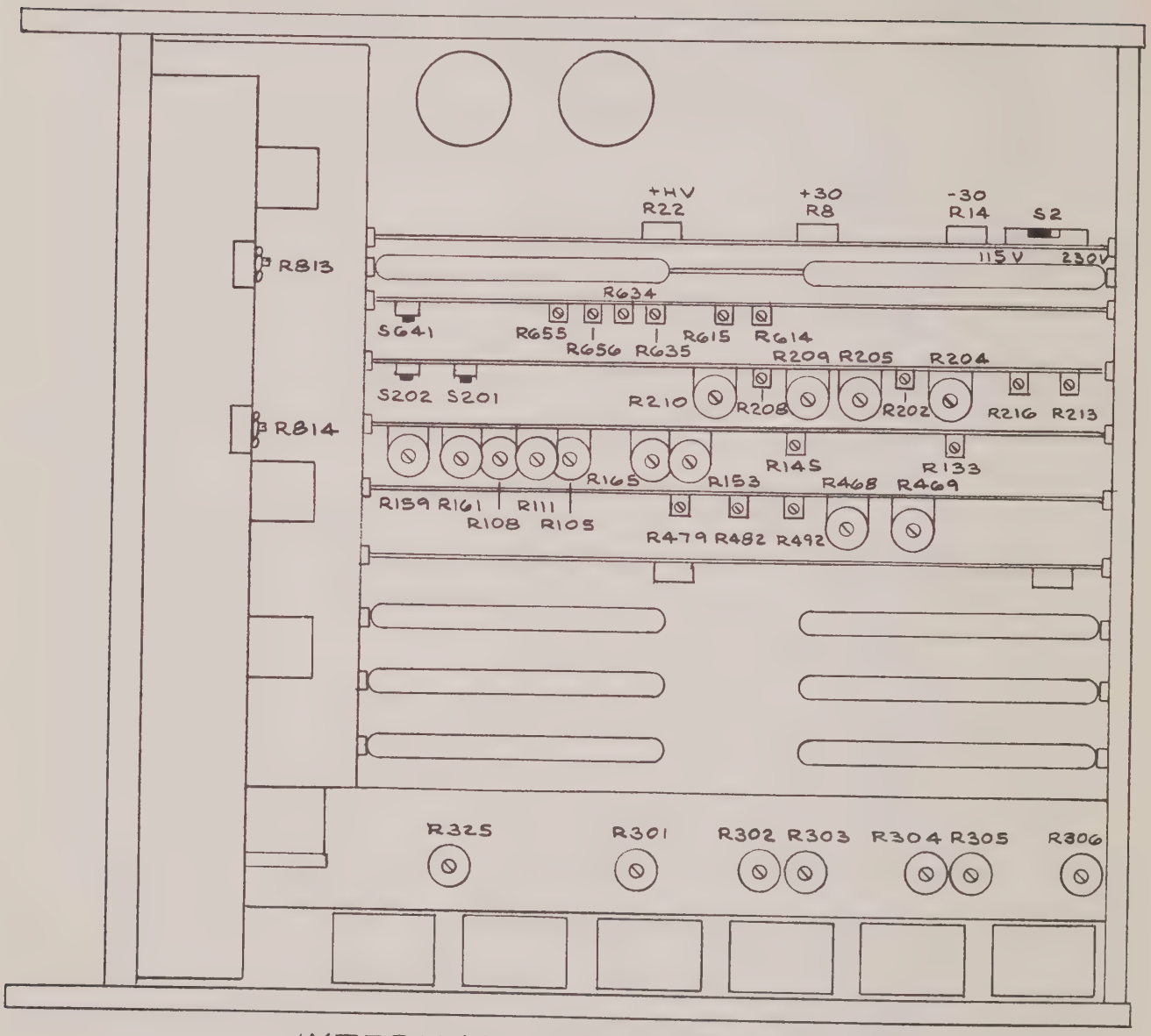
4.2.3 R22, High Voltage Adjust

Adjusts the output voltage of the high voltage supply.

RS-50	+110V
RS-70	+200V
RS-120	+200V

4.2.4 S2, 115/230 Switch

Sets the power line requirements for either 115V or 230V AC.



INTERNAL ADJUSTMENTS

FIGURE 4-1

4.2.5 S641, Pulse Marker Polarity

Determines whether the three pulse markers are positive or negative at the marker adder output.

4.2.6 R655, Variable Marker LO

Adjusts the voltage on the end of the variable marker control to set the range of the pulse marker at the low frequency end of the generator.

4.2.7 R656, Variable Marker HI

Adjusts the voltage on the other end of the variable marker control to set the range of the pulse marker at the high frequency end of the generator.

4.2.8 R634, F_4-LO

Adjusts the voltage on the F_4 control to set the range of the F_4 pulse marker to coincide with the F_3-F_4 sweep at the low frequency end of the generator.

4.2.9 R635, F_4-HI

Adjusts the voltage on the F_4 control to set the range of the F_4 pulse marker to coincide with the F_3-F_4 sweep at the high frequency end of the generator.

4.2.10 R615, F_3-HI

Adjusts the voltage on the F_3 control to set the range of the F_3 pulse marker to coincide with the F_3-F_4 sweep at the high frequency end of the generator.

4.2.11 R614, F_3-LO

Adjusts the voltage on the F_3 control to set the range of the F_3 pulse marker to coincide with the F_3-F_4 sweep at the low frequency end of the generator.

4.2.12 S202, Pen Lift

Sets the pen lift connector on the rear panel to ground during trace or retrace.

4.2.13 S201, Video Blanking

Turns video blanking on or off.

4.2.14 R205, F_4 Sweep Width

Adjusts amplitude of triangular waveform so that when F_3 and F_4 are both

set to the lowest frequency end of the generator, the two waveforms have cancelled out and no sweeping voltage exists on 4 BH.

4.2.15 R208, F_1-F_3 DC Set

Adjusts the level of the upper peak of the triangular waveform at the wiper of R208 to be 0.25 volts more positive than the DC voltage on 4 AS.

4.2.16 R202, F_2-F_4 DC Set

Adjusts the level of the upper peak of the triangular waveform at the wiper of R202 to be 0.25 volts more positive than the DC voltage on 4 AS.

4.2.17 R209, F_1 Sweep Width

Adjusts the amplitude of triangular waveform for the F_1-F_2 sweep.

4.2.18 R204, F_2 Sweep Width

Adjusts the amplitude of triangular waveform so that when F_1 and F_2 are both set to the lowest frequency end of the generator, the two waveforms have cancelled out and no sweeping voltage exists on 4 BH.

4.2.19 R216, F_3-F_4 DC Level

Adjusts the DC level of the triangular waveform on 4 BH for the F_3-F_4 sweep by changing operating point of Q205.

4.2.20 R213, F_1-F_2 DC Level

Adjusts the DC level of the triangular waveform on 4 BH for the F_1-F_2 sweep by changing operating point of Q204.

4.2.21 R159, Manual Limit - Lower

Adjusts the range of the manual control to limit the sweep drive output at the low frequency end of the generator.

4.2.22 R161, Manual Limit - Upper

Adjusts the range of the manual control to limit the sweep drive output at the upper frequency end of the generator.

4.2.23 R108, Auto - Line

Adjusts the voltage to the trigger circuit to allow the rate circuit to free run in auto mode or be line syncronized.

4.2.24 R105, Single Sweep - Trigger

Adjusts the voltage to the trigger circuit to hold off the rate circuit

until a trigger signal is applied or single sweep button is activated.

4.2.25 R111, Line - DC

Adjusts the DC level of the rate generator output voltage in the line sweep mode of operation so that it is equal to the DC level in the auto mode.

4.2.26 R165, Line Trigger Amplitude

Adjusts the rate circuit output amplitude in line sweep mode to equal the amplitude in the auto sweep mode position.

4.2.27 R165, Horizontal DC Centering

Adjusts the voltage on the horizontal to provide a symmetrical about zero horizontal scope drive waveform.

4.2.28 R145, Lower Trigger Point

Adjusts the lower trigger point for the Schmidt Trigger in the rate generator.

4.2.29 R133, Upper Trigger Point

Adjusts the upper trigger point for the Schmidt Trigger in the rate generator.

4.2.30 R479, Balance

Adjusts the operating point of the log stage to set the proper dynamic range of the logarithmic amplifier.

4.2.31 R482, Offsets

Sets the output of the log amplifier to zero with no input signal applied.

4.2.32 R492, Size

Adjusts the output amplitude of the log amplifier to equal the size of the detector by its self.

4.2.33 R468, Balance

Sets the output from the 1 KHz modulator to be symmetrical.

4.2.34 R469, Frequency

Adjusts the frequency of the 1 KHz modulator to 1 KHz.

4.2.35 R717, Drive Level

Adjusts the level of the drive waveform to be symmetrical about zero.

4.2.36 R719, F Sweep Width

Sets the maximum sweep width range of the F_1-ΔF control.

4.2.37 R724, Start/Stop Sweep Width

Sets the maximum sweep width range of the start/stop mode of tuning.

4.2.38 R725, Start/Stop Centering

This control centers the mid frequency at maximum sweep width of the unit in the center of the screen.

4.2.39 R723, Drive Size

Adjusts the linearity near the center of the range of the sweep.

4.2.40 R701 - R706, and R711 - R716 Linearity

Adjusts the linearity of the sweep.

4.2.41 R325, Shaper

Adjusts a filter network which determines the shape of the birdy marker.

4.2.42 R301 - R306 Size

Individual size control for each plug-in marker.

4.2.43 R813, F_1 Substitute and R814, F_2 Substitute

When in the ΔF tuning mode, the F_1 pot, R811, is replaced with R813 set to an amplitude to provide the same sweep drive at maximum sweep width and F_2 pot, R812, is replaced with R814 which when used in conjunction with R813, the proper waveform can be obtained for sweep drive.

4.3 ADJUSTMENT PROCEDURE

The RS Series should be adjusted board by board. After one board is operating properly, and difficulty is encountered with the next board, a checked out board should be inserted in the trouble spot. If this board operates properly, then the trouble is in the harness and should be located before continuing with the new board. Be sure the board contact pins are clean and bright. This procedure must be followed in the order given unless it is known that the boards in the sequence leading to the trouble are all functioning properly.

4.4 INITIAL CHECK

With a bare chassis except for birdy amplifier and RF boxes, insert a power supply board. With an ohm meter, check across the power plug. In

the 115V position, about 15 ohm, and 230V - about 60 ohms should be read on the ohm meter.

Connect the power cord to a Variac, and slowly bring the voltage up while alternately monitoring the +30, -30, and 110V supplies. All the supplies should begin to clamp at some voltage around 95-100V AC input. Proceed to 115V AC and then adjust the supplies for their respective voltages. Then check the supplies for ripple which shouldn't be more than 10 mv. Typically 3 mv.

CAUTION: Do not unplug or insert boards with power turned on.

4.5 RATE CIRCUIT

Insert the rate circuit board, B208-051 in Row 5, and set the front panel controls as follows:

Sweep rate 10-100
Sweep rate vernier fully clockwise
Sweep mode auto

With a scope probe connected to 5 BD or the base of Q108, adjust R133 (upper trigger point) and R145 (lower trigger point) for a triangular waveform of 2V to 20V. If the rate circuit does not free run (no triangular waveform), adjust R108 (auto-line) until it appears, then advance R108 1/4 turn more. Check all 4 positions of rate for proper operation. Check for triangular waveforms at 5 BD and 5 BE. Check 5 BA for -12V DC, and with scope at 5 BB, adjust R153 (horizontal DC centering) for a symmetrical waveform about zero volts. After 5 or 10 minute warm-up, set sweep mode to line and adjust R111 and R165 for a triangular waveform of exactly the same amplitude and DC level as occurred in the auto position.

Set the sweep mode switch to single sweep while observing 5 BD. The triangular waveform should not be present. If it is, adjust R105 until it quits and press single sweep button. One sweep should occur and then reset to its original level.

Next switch to trigger and feed the output of a suitable squarewave generator into the trigger input plug. The trigger circuit should operate or require minor adjustment of R105.

Switch to manual and see if the DC level on 5 BD changes. When the manual pot is turned, R159 and R161 will be set to travel the same range as the single sweep when it is activated.

4.6 START/STOP ADDER

Turn unit off and insert B208-050, dual rate adder board in Row 4.

Set controls same as with rate board.

Plug: Set F_1 against the left stop.
Set F_2 against the right stop.
Set tuning mode in F_1-F_2 position.
Set sweep interval to F_1-F_2 position.
Set F_3 fully counter-clockwise.
Set F_4 fully clockwise.

Connect a scope to 4 AS or junction of R221 and R222. This should be approximately minus 2 volts. Next sit the upper point of the triangular waveform on the wipers of R208 and R202 exactly 0.25 volts more positive than 4 AS. Now connect scope to 4 BH (junction of the drains of Q204 and Q205, and adjust R209 (F_1 sweep width) and R213) to obtain a triangular waveform of 2.5 to 22V.

Now turn F_2 until the pointer is exactly over the pointer for F_1 while still monitoring 4 BH. Set the scope on AC and increase gain of scope. Now adjust R204 until the triangular waveform has been nulled out; straight line. Check for proper start/stop waveform.

Check the collector of Q206 and Q207 for a squarewave of half the frequency of the blanking. Blanking of about 0-25V should be on 4 AT and 4 AP. Set the interval to F_1-F_2/F_3-F_4 and check the source terminal of both Q204 and Q205 for the half frequency squarewave of 25 volts. The two squarewaves should be out of phase one positive when other negative. Set sweep interval to F_3-F_4 and monitor 4 BH. Adjust R126 and R210 (F_3 sweep width) for a 2.5V to 22V triangular waveform. It is important that the triangular waveform for F_3-F_4 be exactly equal to F_1-F_2 in amplitude and DC level. This can be easily determined later with the markers in the unit. Turn F_4 fully counter-clockwise and adjust R205 for a null or straight line as with F_2 in earlier step. A slight readjustment may be required as part of the final set up. Switch the tuning mode to F mode and set the level of the triangular waveform at 4 BH to the same level and phase with the two small pots on the dial drive, R813 and R814.

While monitoring 4 BH, push the dual rate button. A triangular waveform with alternate longer periods should be observed. If not, check Q203 assuming the flip-flop is switching properly. Dual rate works in all, but the F_1-F_2/F_3-F_4 setting of the sweep interval control and line rate.

Set the rate switch to the two slowest settings: .01 to .1 and .1-1, check with a Simpson on the back panel pen lift connector for the reed relay to open and close. S202 determines whether the center pin of the BNC is grounded during trace or blanking time.

Video blanking, Q211, should be checked later after a signal is fed into the detector. Set S201 to the off position, slide toward top of board; no video blanking. It is virtually impossible to set up the log amplifier with the video blanking on.

4.7 LEVELER - LOG AMP BOARD

Set sweep interval to F_1-F_2.
Set sweep mode to auto - about normal viewing rate.
Connect RF output to interval detector.
Install B208-047 - leveler log amp board in Row 6.

Turn on unit. A box pattern should be seen on scope. Check RF level on front panel for proper range (10 db) and set level minimum and level maximum pots on back panel to obtain this range. Set output at 1V rms. Push RF blanking and the retrace line should vanish if video blanking is turned off. Check external monitor or ALC by pushing external ALC button. The output should increase.

With the full output of the generator coupled into the internal detector and the unit connected to an oscilloscope in a conventional manner, a box pattern should be observed with appropriate amplitude depending on the output specification of the generator. Push the log amp button in and adjust R482, the offset control, until the box pattern present doesn't appear to saturate or clamp. Adjust the balance control, R479, until the base line drops down about two/thirds in amplitude. Switch in 40 db and a small box pattern should be observed. Disconnect the RF input to the detector and adjust R482, offset for zero volts DC out. Reconnect the full output RF to the detector and adjust R492, size control, until the pattern remains the same size regardless of the log amp push button switching position.

While monitoring the collectors of Q458 or Q459, push the 1 KHz button and adjust R468 and R469 for best stable 1 KHz squarewave. Check the RF output to see that the output is being modulated at this rate. Check rear panel for blanking out and feed in an AM input for modulation from an audio generator.

4.8 LINEARITY BOARD

Plug in linearity board in Row 7; B208-052. Set F_1-F_2 against their respective stops.

Sweep interval F_1-F_2
Sweep mode - auto and reasonable viewing rate.
Install marker - HM-50.

Turn on unit and set the wiper of R717 to give a triangular waveform symmetrical around zero volt. The input should be 2.5 to 22V. Set the tuning mode to F_1-F_2 and by adjusting R724 and R723 (drive size) the output should be swept and birdy markers present. If not, check for varactor drive voltage on the proper feed-thru in the oscillator. If it is present, check the birdy amplifier board and sweep sample. After proper markers have been established, adjust R724 to have a 1.8V peak waveform and R719 to have a 2.2V peak waveform on their respective wipers. Adjust R725 to center 250 MHz on screen. Now adjust the drive

size to set the 200, 250, 300 MHz markers on the three center gradicules. Now set the rest of the pots in the diode shaper until a 1% linearity is obtained. With a calibrated scale, set F_1 at zero and F_2 at 500 MHz. Adjust R724 and R725 until 0 falls on the left edge and 500 MHz falls on right edge of the box pattern. Now with the scale, check calibration of F_2 as it is turned toward F_1 and also F_1 toward F_2. Set F_1 to 100 MHz and R738 and R730 will be set by switching tuning mode to Fo/ΔF. Set blue pointer (Fo) at zero and adjust R738 until zero center frequency appears. Set Fo at 500 MHz and adjust R730 until 500 MHz appears in center. This will require repeat adjustment due to interaction of controls. Set Fo at 250 MHz and F_1 at 500 MHz, adjust R719 for 0 to 500 MHz sweep. Feed in a 60 cycle signal on the gate of Q704 or 7 BR lock/FM input and watch for markers slight shift. If they do, then the external phase lock and FM input works.

4.9 PULSE MARKER BOARD

Install board, B208-049 in Row 3. Set controls as follows:

Tuning mode - F_1-F_2
Sweep interval - F_1-F_2 markers.
Sweep mode - auto
F_1 and F_2 against their stops.
F_3 and F_4 near midrange.
Variable marker - 250 MHz.
Pulse marker size - fully clockwise.

When turned on, three pulses should be present on the trace. If not, adjust F_3, F_4, and variable marker until they are. S641 determines the polarity of the pulse. The unit will be shipped with positive going pulses. The variable marker pulse is approximately 15% smaller in amplitude. Each pulse has two internal pots which determine the range of the pulse. F_3, low, R614, sets the position of the pulse on the left end of the sweep with F_3 (FP) set fully counter-clockwise and F_3, high, R616, sets the position of the pulse on the high end or right end of the trace. The same applies for the corresponding set of pots for F_4 and variable marker. The variable marker and F_3 and F_4 should be checked and set so they will travel the full range.

Set the variable marker pointer (blue) on zero frequency on the scale and adjust R655 until the pulse overlaps zero. Run pointer to 500 MHz and adjust R656 until pulse overlaps 500 MHz birdy. Repeat this adjustment until calibration tracks.

F_3 and F_4 pulses will be set as part of the final setup.

4.10 FINAL SETUP

Allow 15 minutes warm-up time.

Set sweep interval - F_1-F_2/F_3-F_4.

F_1 and F_2 against their respective stops.
F_3 fully counter-clockwise.
F_4 fully clockwise.

The dual trace pattern presentation must overlap so that each birdy lies exactly on top of the other. Some readjustment of adder circuitry, R213, and R209 may be needed to achieve this requirement. To set F_3 and F_4, switch sweep interval to F_3-F_4 and decrease sweep width with F_3 and F_4 around the 50 MHz marker until as narrow as possible and still see a birdy. Now switch sweep interval to F_1-F_2 markers and adjust F_3, low (R614), and F_4, low (R634), until both pulses line up over the 50 MHz birdy. Switch sweep interval back to F_3-F_4 and now decrease the sweep width around 450 MHz birdy with F_3 and F_4. Switch back to F_1-F_2 markers and adjust F_3, high (R615), and F_4, high (R635), until the pulses line up over the 450 MHz markers. Repeat the setup for F_3 and F_4 due to interaction of the internal pots. Now set sweep interval to F_1-F_2 markers and position the markers around zero, and switch to F_3-F_4, and see if the portion between the pulse markers is displayed. Repeat for every 50 MHz birdy marker. The accuracy is $\pm$3% or each marker could be off as much as 30 MHz.

Push marker clip and see if the birdy marker is clipped off. Look at the horizontal waveform and push tilt button, birdy markers should be present on the horizontal triangular waveform.

Double-check:

Sweep mode - line and auto box pattern exactly same size.
Manual sweep travels same range as single sweep.

4.11 VIDEO AMPLIFIER AND OSCILLATOR

These two sections are very critical and if adjustments are required, the adjustments should be made at the factory.

WARRANTY

Products manufactured by Texscan Corporation are warranted against defective materials and workmanship for one year from date of shipment. Any instrument or component which has been found to be defective during this one-year period will be repaired or replaced without charge except for vacuum tubes or batteries which have given normal service. No other warranty is expressed or implied. Texscan is not liable for consequential damage.

ORDERING INFORMATION

In the United States and Canada, please order through your local representative or directly with the factory. Your factory trained representative can supply technical data and latest price and delivery quotations.

The factory address is:

Texscan Corporation
2446 North Shadeland Avenue
Indianapolis, Indiana 46219
Phone: 317--357-8781
TWX: 810--341-3184
Cable Address: TEXSCAN

In Western Europe, please order through your local representative, who can supply technical assistance and up-to-date price and delivery information.

Complete addresses and telephone numbers of Texscan's sales representatives are listed on the outside back cover of the catalogue.

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order, we shall use our own judgment as to the best method of shipment. Unless otherwise specified, normal shipments will be by air freight or air express. Small items are sent via parcel post. The listed price for our products include the packing, but does not include the cost of shipping.

CONDITIONS OF SALE

Determination of prices, terms, conditions of sale, and final acceptance of orders are made only at our plant in Indianapolis, Indiana

All prices are F.O.B. Indianapolis, Indiana, USA.

Terms in the United States and Canada are Net 30 days if credit has been arranged.

Terms throughout the rest of the free world are arranged with Texscan's area representative.

SERVICE AND PARTS

Repair service is available at our plant in Indianapolis, Indiana. Before returning an instrument for repair, please write to us, requesting a Returned Material Authorization. On receipt of shipping authorization, forward the instrument prepaid. Care should be taken in packing the instrument to insure protection in transit. Also, state the type and serial number of the instrument, date of purchase, and details concerning the difficulty.

Repair parts may be ordered from our home plant or through our sales representatives. When ordering repair parts, please specify the part number and description of the item, and the type and serial number of the instrument in which it is used.

SPECIFICATION CHANGES

The right is reserved to change the published specifications of equipment at any time, and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold.